Fermilab

SiDet JHA/WORK PERMIT

JOB NAME: ISL Laser (Nd:YAG) Tests

LOCATION: Carrier Room at SiDet

Job Duration: from 20-May-03 to start of 2003 summer shutdown

Laser Description: Class 4 Nd:YAG industrial laser (λ=1064 nm) with a maximum power output 60 W, air cooled, with external interlock enable. Also has a low power HeNe laser (class 1) for use in targeting.

Laser Owner: Bob Kephart (x3135)

People performing work: CDF personnel

DESCRIPTION OF WORK: The CDF Intermediate Silicon Layers (ISL) have 12 blocked cooling lines. In mid September, using custom borescopes, the problem lines were observed to be blocked with epoxy. After investigating several possible means for removing the epoxy, it was decided that the safest and most controllable method was the use of a Nd:YAG laser. Prior to *in situ* use of the laser, it is necessary to demonstrate the safety and reliability of this method. The tests performed in this room are aimed at developing a safe and reliable means for removing the epoxy blocks, while leaving the cooling tubes unharmed.

- **Safety** – all of the safety recommendations made by Tim Miller and Dave Baird, as detailed in the attached document, have been implemented. In particular:
    - Light tightness: the room has been made light tight, thus establishing the room itself as the nominal hazard zone.
    - Protective eyewear: 4 pair of appropriately rated safety goggles will be available in the laser room; this will limit the number of people that can be present while the laser is enabled; an extra-pair will be left outside the Carrier Room door, and clearly labeled for use in emergency only.
    - Interlocks: the door to the room is interlocked in such that when it is opened, the laser enable is automatically dropped. In addition, the laser interlock itself requires a key to enable it. This key will be locked away in a key tree in the absence of a designated laser operator.
    - Authorized personnel: all personnel performing the work have taken the appropriate laser-training course. In addition, the number of people in the room while the laser is enabled will be limited to four. The laser will not be enabled without the presence of at least one laser operator – qualified personnel are listed at the end of this document. If more than one qualified

laser operator is present, only one shall be designated the ``lead'' operator. It is the responsibility of the (lead) laser operator to ensure that everyone present is wearing protective eyewear and is standing outside the "clearance zone" prior to firing the laser.

- Signs: the Danger signs, as specified by the LSO, will be posted on the door at any time the laser is enabled. It will be removed during those times that the laser cannot be enabled (ie. the interlock key is removed).
- Labels: the laser itself has been appropriately labeled as per the LSO and ESH.
- Emergency procedures: since the laser interlock enable is automatically dropped when the room door opens, it will be safe for anyone to enter in the event of an emergency. As an extra precaution, an extra pair of safety goggles will be available just outside the Carrier Room door for use in an emergency.
- Energy Dissipation: we will not be operating the laser at power-settings which require us to worry about dissipating excessive heat.
- Beam intensity vs distance: attached is the calculation from Tim Miller (and cross-checked by Doug Glenzinski) regarding ocular and dermal exposure limits as a function of distance from the laser end. Assuming the maximum power output, there is nowhere in the room far enough away that ocular damage can be avoided; for this reason, protective eyewear must always be worn while firing the laser. Risk of dermal damage is eliminated, even for maximum power output, at distances of at least 1 meter from the laser end. A 1 meter "clearance zone", centered on the target, will be marked on the floor, and all personnel will be required to stand outside that zone when firing the laser. The designated laser operator will be responsible for ensuring that everyone present meets these safety requirements prior to firing the laser.
- Diffuse Scatter: prior to firing the Nd:YAG laser, the class 1 HeNe laser can be used to ensure appropriate targeting. In addition, an effort will be made to blacken or otherwise limit the scatter in the area of the target.
- Written Procedures: the procedures for targeting and firing the laser are given on the following page. All personnel working in the room will be required to read and sign this document.

Procedures for Operating the ISL Nd:YAG laser at SiDet

All personnel working in the Carrier Room at SiDet will have agreed to obey the following operational rules.

General:

1) There will be a single designated laser operator. Qualified personnel are listed as "laser operator" at the end of this document.
2) Only the laser operator can enable and fire the laser.
3) When firing the laser, all personnel present will be wearing protective eyewear, will stand outside the 1 meter clearance zone and otherwise follow the instructions of the laser operator. These safety conditions will be maintained until the laser operator announces that it's safe to do otherwise.
4) The "Danger Class-4 Laser" signs will be posted during those periods of time that the laser is or is likely to be enabled. These signs will be removed when no work with the laser is being performed.
5) While no work with the laser is being performed, the interlock key will be removed and locked in a key tree.
6) Prior to firing the Nd:YAG laser, the laser-target alignment can be checked using the HeNe laser.

Firing the laser (laser operator only):

1) Check that the laser fibers and the target are securely fixed.
2) Limit as much as possible the potential for scatter from the target. For example, blacken the area around the target, cover or shield the target w/ appropriate materials (herculyte + black-out paper sufficient at low power settings).
3) Instruct everyone present to step outside the clearance zone and to put-on protective eyewear.
4) Check the power settings, the pulse duration, the repetition rate and the total duration of the firing, using the laser keypad.
5) Verify that all personnel present have complied with the safety instructions given in step 3).
6) Open the laser shutter using the keypad.
7) Announce that you're ready to fire.
8) Fire the laser.
9) Close the laser shutter using the keypad.
10) Announce that it's safe to remove eyewear and approach target.

1. **Studies** - the following will be investigated using the set-up in this laser room
    - Coupling the output of one fiber to the input of another
    - Appropriate laser power settings to remove epoxy but leave aluminum cooling pipes unharmed
        - In air
        - In water
        - When fiber has to accommodate small bend radii
    - The use of straight-firing, side-firing and bundled fibers as a means of delivering the laser

The development of the couplings will use a class-1 HeNe laser, available with the unit for targeting, to help optimize the set-up. This laser poses no exposure hazard. Tests w/ the Nd:YAG laser will typically use power settings of a few Watts per pulse, and will only be fired away from personnel into a power-gauge, epoxy block or the ID of an aluminum tube. Initial tests will all be performed in air, though later tests will introduce some water into the aluminum tubing. Final tests will involve the use of a full-scale mock-up of the ISL. The external reflective surfaces of the mock-up will be blacked-out in order to avoid a random reflection of the laser should it pierce the aluminum tubing during tests. The laser will not be operated without the presence of at least one laser operator (as given above), one of whom will serve as "team captain" at all times. There will be a maximum of 4 people allowed in the room during testing. Prior to firing the laser, the HeNe laser can be used to ensure correct targeting.

ASSOCIATED HAZARDS:

Laser hazard: Ocular damage possible w/o the use of appropriate safety goggles. Dermal damage possible if focal distance less than 1 meter at maximum power.

HAZARD MITIGATION:
All personnel participating in the work will have taken the appropriate laser safety training course.

Safety goggles will be worn whenever the laser is enabled. At no time during these tests should there be occasion for having the laser directed at a person.

Typically, the laser will operate at a much reduced power (few watts per pulse) compared to its maximum capability of 60 W. Personnel will be at least 1 meter away from end of laser fibers when in operation.

The laser will be interlocked with the entrance door to the laser room. Opening the door will drop the interlock enable, automatically turning-off the laser. The room will be locked. In addition, an interlock key at the face of the laser is required to fire it. This key will be locked away when the laser is not in use.

Fibers are jacketed and all optical couplings will be appropriately shielded.

All the safety recommendations detailed in the attached document will be implemented in full.

A pre-operation meeting will be held with the crew members to discuss the work to be performed.

PREPARED BY: Doug Glenzinski 27-Sep-01 (Amended Ken Schultz 5/12/03)

APPROVED BY: John Cooper (PPD) -
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APPROVED BY: Martha Heflin (ESH) -
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APPROVED BY: Tim Miller (Laser Safety Officer)
_____
or Dave Baird

APPROVED BY: Marcel Demarteu (SiDet) -
_____
or Brenna Flaughter

APPROVED BY: Doug Glenzinski (lead physicist, laser operator)
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APPROVED BY: Ken Schultz (lead tech, laser operator)
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SIGNATURE LIST OF WORKERS INVOLVED IN THIS TASK

The supervisor has reviewed this Work Plan & Hazard Analysis with me and I understand the hazards and required precautionary actions. I will follow the requirements of this plan or notify my supervisor if I am unable to do so.

Name (print)	ID#	Signature	Date
Rich Stanek (laser operator)			
Bob Kephart (laser operator)			
Jeff Spalding (laser operator)			
Andy Hocker (laser operator)			
Julia Thom (laser operator)			
Cigdem Issever (laser operator)			